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THE ESSENTIAL NEEDS OF MODERN NAVIGATION.

BY

G. W. LITTLEHALES.

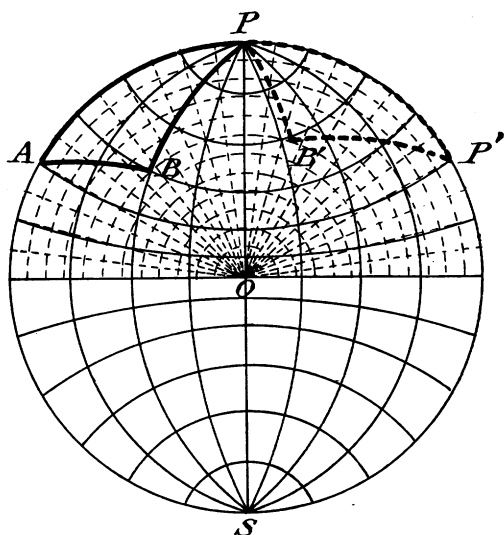
The substance of the science of ocean navigation is comprised in the deduction of position and direction from observations of celestial bodies, or in enabling the navigator to find the place where he is and the direction of the place to which he is to go. The greatly-increased speed of ocean vessels of the present day has necessitated more frequent observations to ascertain the ship's position and the errors of the compass, and it is highly desirable that laborious and extended systems of calculation should be obviated and that some short, sure, and simple method should be made available to the navigator, by means of which he shall be able to deduce the results of his celestial observations before the ship has moved far from the place where the observations were taken. A thoroughly satisfactory method of effecting the graphic or mechanical solution of almost any of the elements of the astronomical triangle would probably be turned to use at once among navigators. For example, if a method should be brought out for conveniently obtaining with the required accuracy, in a few minutes, the altitude and azimuth of a celestial body from its declination and hour-angle and the estimated geographical position of the observer, navigators and geographers could at once employ the method to advantage in finding the Sumner's Line of Position. For an observer, having measured and found the true altitude of a celestial body and then deduced the altitude and azimuth of the observed body due to the estimated position of the ship, could draw a line on his chart through the estimated geographical position of the ship at right angles to the azimuth of the observed celestial body, which might be appropriately called the Sumner's Line of Position by Account; and next, comparing the instrumentally-measured true altitude with the altitude due to the estimated geographical position, he could at once draw the actual Sumner's Line of Position, since it would be sensibly parallel to the Line of Position by Account and removed from it by a perpendicular distance equal to the difference in minutes of arc between the observed and deduced altitudes and toward the direction of the observed celestial body or away from it, according as the true altitude obtained by observation is greater

or less than the altitude deduced by dependence on the estimated geographical position.

It may, therefore, prove of value to indicate a way in which it is probable that the altitude and azimuth of any celestial body may be found simultaneously and without calculation.

The accompanying figure represents a stereographic projection of the celestial sphere on the plane of the meridian.

If the latitude of the observer be laid off along the bounding meridian at A, and the declination of the observed celestial body



be laid off at B along a meridian making an angle with the bounding meridian equal to the hour-angle of the observed celestial body, an astronomical triangle will be formed in which the known parts are the two sides PA and PB, representing respectively the co-latitude and co-declination, and their included angle APB, which is the hour-angle of the observed celestial body. The unknown parts of this tri-

angle are the azimuth, PAB, and the co-altitude, AB, of the observed celestial body. If the triangle, PAB, were revolved about the central point of the projection, with the side, PA, kept in coincidence with the bounding meridian, until the point A is brought to the position of the point P, the latter would then occupy the position P', and the point B would fall at B', so that the unknown side of the triangle, representing the co-altitude, would lie along some meridian, and could be measured from the graduation of the projection, and the unknown angle, representing the azimuth, would become an included angle between two meridians, which could likewise be measured from the graduations of the projection. And thus the altitude and azimuth of any observed celestial body could be read from the diagram with any degree of precision that the scale of the projection might permit. To obviate the necessity for the actual revolution of the triangle, as

described above, a series of equally-spaced concentric circumferences and a series of equally-spaced radial lines have been drawn over the projection in lines of dashes. For the purposes of identification, the overlaid system of concentric circumferences should be numbered serially from the centre of the projection outwards to the bounding meridian, and the radials should also be marked by numbers indicating their angular distance in minutes of arc counted in a clockwise direction from some fixed origin, like the line OS; so that, having plotted the declination and hour-angle of the observed celestial body at B, it is only necessary to note the number of the circumference and the number of the radial which pass through this position, and then, adding the co-latitude expressed in minutes to the number of the radial, find the intersection, B', of the noted circumference with the radial whose number is the sum just found, and read off from the graduated arcs of the projection the altitude and azimuth of this point of intersection.

In order that such a method may displace the longer and laborious methods of obtaining the results by calculation, it is necessary that the scale of the projection should be large enough to admit of plotting the data and reading off the results to the nearest minute of arc. To provide for such a scale, the stereographic projection would have to be constructed with a diameter of about twelve feet, which, in one continuous sheet, would be of unmanageable size for ordinary use. It is certain, however, that such a projection could be reduced to convenient dimensions for use by being cut up into overlapping sections about the size of leaves of a book, and used with the same facility as if preserved in one continuous sheet; for it has been pointed out that, in carrying out the proposed method of solution, only those parts of the projection are involved which lie in the immediate vicinity of the points whose coordinates are to be plotted or read off.

U. S. Hydrographic Office.